Chapter 3

Virtual Reality for Preservation:

Production of Virtual Reality Heritage Spaces in the Classrooom

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Abstract

The Bethel AME Church was the oldest African American church in Indianapolis. In November 2016, the congregation moved out of downtown, and the building that had housed the congregation since 1869 was sold. It is now being redeveloped into a hotel. Through the Virtual Bethel project, faculty and students in the Media Arts and Science (MAS) program at Indiana University–Purdue University Indianapolis (IUPUI) created a 3D virtual space of the physical sanctuary to preserve the cultural heritage of Bethel. During its creation, Virtual Bethel served as a curricular and co-curricular experience for the undergraduate students in the 3D graphics and animation specialization within class N441 3D Team Production, which was co-taught by Albert William and Zebulun Wood. Virtual Bethel, finished in 2018, was the first historical and cultural preservation project that used VR within our class, program, school, and Indiana University (IU) campus. Users can interact with various types of primary sources (e.g., photographs, video, audio, text) to learn about the underrepresented history of African Americans associated with the church. Virtual Bethel was created in a series of classes within the MAS Program in the School of Informatics and Computing (SoIC), IUPUI. Methods of

Virtual Bethel was funded by an Indiana University New Frontiers Grant in 2017. The authors would like to thank the team of the Advanced Visualization Lab (AVL), IUPUI: Thanks to Jeff Rodgers, Chauncey Frend, Tyler Jackson, and Michael Boyles for their unrelenting support of our programs and all-too-often thankless hours they put into our projects by fielding questions and inspiring all. We thank the students of Virtual Bethel, first Luke Brown for coming onto the project to embed and build a VR storytelling database, the first of its kind at IU, and for being at every public showcase and documenting everything. Thanks to original team Tyler Jackson, Rachel Davidson, Bryan Dinkens, Thomas Springer, Roxanne Wheeler, and Charles Yu, and to Skip Comer and Lisha Chen for creating our website and the ability to provide Virtual Bethel to the world.

We thank Online Resources, Inc. for the original 3D scan of Bethel AMC, and Kisha Tandy for providing research and for assistance in curating the Virtual Bethel Vignettes. Finally, we thank the Bethel AMC Congregation, especially Olivia McGee-Lockhart, for curating the mission, public showcases, vignettes, and accuracy of content within Virtual Bethel. Thank you for your continued partnership with our students, school, and university.

teaching a team of students to preserve historic spaces using VR are discussed, as are our philosophies toward productions when working with varying stakeholders' priorities related to data preservation, asset preservation, and cultural preservation.

Project Background and Significance

The Media Arts and Science (MAS) program in the School of Informatics and Computing (SoIC) provides undergraduate courses in 3D production and visualization. As a project-based course, N441 3D Team Production is designed to involve community partners in providing students with real-world, context-driven, hands-on learning opportunities. The course focuses on the creation of high-end, broadcast-quality animations through team-based learning. Students learn skills in areas related to production in a 3D project. These skills include preproduction tasks such as the development of a story, script writing, research, conceptual drawing, storyboarding, animatics, and project management. Production skills are explored in 3D asset creation, time management, file management, sound, and title sequences. Postproduction processes include final rendering, movie creation, and formatting for various playback devices. More recently, the program has embraced projects implementing and leveraging emerging technologies such as 3D printing, VR, and augmented reality (AR).

Founded in 1836, the Bethel AME Church was once a vital part of a thriving African American community in the heart of the Indiana Avenue Jazz District. Before that, Bethel played a vital role in the Underground Railroad. Bethel has significant meaning not just in African American history, but also in the local heritage of Indianapolis. Recently, the church site was rezoned for redevelopment, leaving the historic building—and the materials housed in the church archive for more than 162 years—in a vulnerable position.

Although the effort to digitally preserve the at-risk physical space is not innovative in and of itself within cultural preservation domains (e.g., Arc/k Project,[1] CyArk,[2] Iconem,[3] MasterWorksVR[4]), the Virtual Bethel[5] project incorporates associated digitized and born-digital archival materials into the virtual space to provide a new way of learning history and interacting with Bethel's primary sources. The project intends to develop this space as a virtual learning environment for undergraduate students' history and primary source education. The methods used to develop Virtual Bethel by engaging undergraduate students will be relevant to studies of other historic sites and archives with similar ambitions.

[1] http://arck-project.org
[2] https://www.cyark.org
[3] http://iconem.com/en/
[4] http://masterworksvr.com
[5] https://comet.soic.iupui.edu/bethel/

Community: Respecting the Heritage and Institution's Members

Communication among the undergraduate N441 3D Team Production class, Bethel's church membership, and local historians connected the students easily with Andrea Copeland, chair of the Library and Information Science Department in the SoIC at IUPUI. Copeland focuses her research on facilitating connections between groups typically underrepresented by heritage institutions and community preservation infrastructures. Her research finds that trusted relationships are essential for reducing social distances and building connections among individuals, institutions, and knowledge. She has worked for several years with congregants from the Bethel AME Church. Working together on this project, we learned valuable lessons that can be used to support future community-driven heritage projects.

Course Description and Necessary Skills for Restoring 3D Scanned Structures

The N441 3D Team Production class allows students to work as a group and emulates the collaborative team environment found in the media and animation industry. The goal of the course is to bring students together to work on a common project. At this point in their undergraduate degree program, students have completed a number of prerequisites, including intermediate courses in 3D modeling, texturing and lighting, and animation. Virtual Bethel served as the first cultural preservation project using VR as a medium to engage students with the aim of educating the public. Regardless of the project assigned, students are encouraged to bring their existing knowledge and specialty (e.g., modeling, unwrapping, shading, materials, lighting, game development) to the team and investigate new skill sets that they may want to develop or that are needed to facilitate the success of the production.

We have found through teaching this course for five semesters over five years that students engage in this class for a variety of reasons with a range of positive outcomes. The course allows them to work together on a single project synergistically. Students can apply their existing skills and also find ways to implement other interests that they may not have yet developed. The course teaches them team dynamics and develops skills essential to the success of group work, including communication, leadership, organization, and accountability. Past class assessments indicate that the experiences students have in this class are far beyond regular class work in contributing to a larger team and serving the community, that they relish this experience, and that the overall result is a very satisfying academic exercise (Lombardi 2008; McLeod 2017).

At the beginning of class, we assess student strengths to compare the existing skill sets with a project's goals. We carefully look at student abilities, often recruiting students that we feel might benefit

from the experience and who can contribute specifically to certain portions of the project as it develops. We expect strong student leadership from within the group and encourage students to be accountable to their peers rather than to the instructors. We set up a data and communication structure that ensures all students begin interacting as soon as the class starts. We encourage the students to adopt a communication system that is easiest for them; many times, students have opted to use Facebook or other social media platforms. They also communicate daily and share files through a system used in the Indiana University infrastructure called IU Box.

Technical knowledge of the craft (in this case, animation) is, of course, critical to the success of the project; yet the students are encouraged to research the topics on their own early in the semester. Supplementary materials are gathered and provided in our course materials on Canvas, the campus learning management system. Knowing the history of the subject or the background of the story gives students more interest in the success of the project and their role within it.

The Classroom as a 3D Production and Preservation Studio

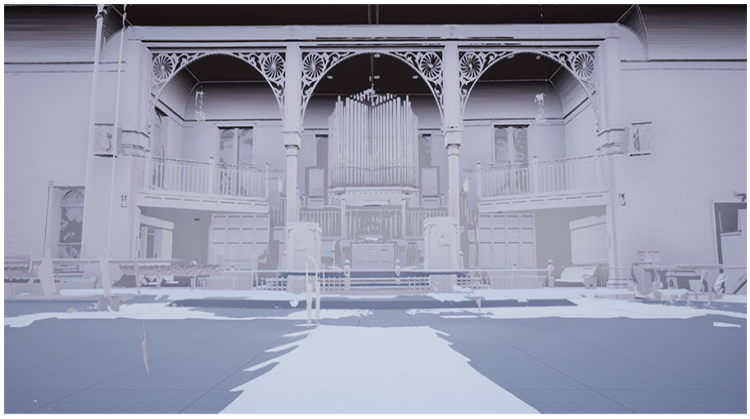
In the fall semester of 2016, our N441 class was presented with the opportunity to re-create the historic Bethel AME Church in Indianapolis. We felt that a VR experience using 3D models and textures would be a powerful method of telling the story of this church. We also felt that this opportunity for community engagement was a perfect fit with the collaborative nature of the class, as IU strives to highlight its engagement and impact throughout the state. We presented the students with this opportunity in the first class meeting. They considered this a great use of their skills and time, and they were excited to be working to give back to the downtown Indianapolis community.

During our second class meeting, all students and faculty visited the church, which was within walking distance of our classroom, to experience the space that we would re-create. In early September 2016, on a warm, late afternoon with sunlight streaming through the stained glass windows, we spent more than two hours exploring every corner of the church. We took about 2,000 high-quality photographs to use as reference for the 3D models and textures that would go into the VR experience. We used a GigaPan robotic camera system to capture images that were stitched together to form highly detailed panoramas of the interior, and a Ricoh Theta camera captured low-resolution 360-degree images. All of these photographs were cataloged, archived, and used to help re-create the digital space. Measurements of some structures were also taken as references for scaling the models.

Before the start of the semester, Online Resources, Inc., a local 3D scanning company, had created laser scans of the interior of

the Bethel AME Church for the project with a 100mm Surphaser LiDAR laser scanner. This data set was approximately 2.9 GB and contained 39 million polygons. Tests of the scanned data using the Unreal 4 game engine outputting to an HTC Vive VR system showed that, because of the density of the scanned mesh and size of the data set, we had to greatly reduce the scan so we could view Bethel in VR. The group decided early on to use the scan as a type of digital tracing paper, an excellent reference resource that could speed up our modeling workflow (figure 3–1). One of the first steps taken as we started to develop the church interior was to bring the reduced scanned data into Unreal and scale it correctly. We simply placed a six-foot box representing the size of a human and compared it with the objects and space within the scene.

Fig. 3–1. *The original LiDAR scanned data (top), retopologized interior (middle), and fully textured and lit Virtual Bethel ready for viewing in VR (bottom)*



Laser scan model provided by Online Resources, Inc.

Recreated 3D model of Bethel AMC from laser scan

Fully textured and lit Virtual Bethel

Students used Autodesk Maya 2016 as the software to model all of the assets. The scanned data were reduced using Pixologic Zbrush's decimation tools, then brought into Maya and scaled to their proper dimensions for use as a template. Objects that had been measured by students were used as references, and then the scanned model was brought to its proper relative scale based on unit settings (mm, cm, meter) in Maya.

Using the scanned data and reference photographs, our modelers were able to determine the basic shapes of each part of the specific objects and begin manual reconstruction. We needed to be cognizant of the number of polygons that this model contained so that it would show enough detail, but the number could not be so high as to hinder the Unreal 4 engine executable file when it was brought to VR and displayed in stereoscopy.

Production meetings, in which iterations of the virtual environment, individual assets, and interactions in the virtual environment were discussed, were held at the beginning of each week's class in a conference room, instead of our usual classroom. This allowed students to focus on all of the assets, brought them together as a team, and showed them how their contributions were affecting the big picture. The

team reviewed each student's work weekly, addressed concerns as needed, then tasked the students with moving forward on new assignments. We, the instructors, stressed to each student that others relied on their progress and thus adherence to deadlines was mandatory. Production meetings were followed by visits to the IU Advanced Visualization Lab[6] to view the progress on the VR environment within the Unreal game engine. After the team meetings, the rest of the class was dedicated to lab/production time for all members to spend time interacting, working, and receiving individualized instruction from both faculty and team leads as needed. On artistic or preservation considerations, the students considered feedback from the client/public and adjusted the interactives based on the audience's reaction to the environment, primary resources within VR, or even the VR hardware itself. As we neared completion, some church congregation members and the church's pastor visited to see our progress. It was surreal to watch the members find the pew where they had always sat and to observe the pastor stand in his favorite spot to give a sermon. The students saw the impact of their work on the visitors and started to understand how this project was important for the community. This was a very powerful visit for all involved.[7]

As students completed 3D models for populating the VR environment, they kept records of their progress on a spreadsheet. As digital models were completed, students began unwrapping the 3D objects so they could be textured using Allegorithmic's Substance Painter. This process applied materials and colors to the 3D models to give them a sense of realism. To simplify the identification of particular materials, an internal team library was created for students to access materials that had been identified in Bethel. Materials represented surfaces in the real world (e.g., types of wood [cherry, oak, poplar], paint [glossy, matte, aged], metals [chrome, copper, iron], plastics [silicone, rubber, shiny, glossy]). As models were painted within Substance Painter, texture maps were exported for use in Unreal 4's physically based rendering (PBR) shaders, which experts in the video game and architectural visualization industry commonly use to make surfaces appear realistic.

After all models had PBR materials applied and were loaded into Unreal, various processes were used to optimize the scene. For example, the textures were tested to see whether there were errors, lighting was added to the scene to simulate light coming through the windows, navigation controls were optimized, and teleportation locations were created to permit navigation in the environment.

[6] https://kb.iu.edu/d/apel

[7] See a short video of Virtual Bethel in early production used to solicit additional support: Virtual Bethel Solicitation, October 14, 2016. Available at https://vimeo.com/187085145

Building a Campus Infrastructure for Virtual Preservation of Cultural Heritage

In projects such as Virtual Bethel, the prior knowledge, resources, and communication ability of support staff, faculty, project partners, and client partners are critical to project planning. Readily available hardware and software can ensure the success or guarantee the failure of projects. The MAS faculty have made several choices and adopted specific philosophies to ensure success across media projects of many kinds. Following are discussions of specific considerations concerning VR projects involving the digital preservation of spaces, including technical considerations; associated costs; student technical and artistic competencies; variations in student level of confidence and leadership; variations in peer-to-peer organization, communication, and accountability; and student learning outcomes.

Technical Considerations

The MAS program faculty and students make every effort to stay software agnostic, especially in relation to game development engines. In an age when software updates are daily and software companies are purchased every hour, it is impossible to anticipate which updates, plug-ins, or software will stop being supported or will be changed entirely. We encourage our faculty and students to test, vet, and hone their skills on multiple platforms. The Unity game development engine tends to enable easier porting to various head-mounted devices (HMDs), mobile devices, and app stores, while Unreal, until recently, has supported only higher rendering and realism capabilities. We built Virtual Bethel using the Unreal game engine because we wanted to develop contained systems for porting Virtual Bethel onto full VR, mobile devices, and web environments for maximum public access. This was a new process for us, and future projects in the program will benefit from the lessons learned.

Another important technical consideration is that 3D scans of objects, spaces, or both must be completed and delivered before the start of a production course semester. Geometry created from scan data is often best at the highest possible capture settings. Whether the data are captured via LiDAR, structured light, photogrammetry, or by other means, the bigger the dataset, the bigger the textures, and the larger and more frequent the photos, the better the end result. Given the temporal constraints of the academic semester, student productions cannot be delayed because of the need to recapture or find additional photography.

Associated Costs

VR projects like Virtual Bethel have substantial costs. The total support funded by Indiana University's New Frontiers Grant[8] in 2017 was considerable at roughly $59,000. Most of the funds covered the costs of student hourly labor outside of class time (texture artists, lighters, game developers, web developers, user experience [UX] researchers), faculty summer support, and a modest honorarium for our community partners. Nearly 10 percent of the budget was used to purchase server space for the website and invest in a mobile VR workstation with a laptop capable of showcasing iterations of Virtual Bethel to the public during its production so that students could receive feedback (Copeland et al. 2018).

Without an MAS or similar program, an institution is unlikely to have the necessary resources for such projects, including lab space, and hardware and software. The lab space, computers, display hardware, and 3D and game design software had already been purchased for teaching MAS students in the undergraduate and graduate program within SoIC, IUPUI. The core labs, IT 255 and IT 257, house 43 computers with Cintiq displays with the latest software and hardware for film, game and VR art, production, and development, as well as VR hardware, respectively (figure 3–2). Unless this infrastructure and the supporting IT staff already exist, projects like Virtual Bethel would be unreasonably expensive.

Fig. 3–2. *3D (left) and VR production (right) labs at the School of Informatics and Computing*

In terms of labor, the three to five MAS students who worked during the digital replication of Virtual Bethel averaged a total of 15 hours per week, followed by two students who averaged ten hours per week in labor in the second semester, and one student who worked over the last eight months embedding audio, interactions, and iterating on the story vignettes within Virtual Bethel once the project was funded at an average of 10 hours per week. Two students were paid outside of class after the first semester through the support of the IU New Frontiers grant for two additional semesters

[8] https://research.iu.edu/funding-proposals/funding/opportunities/new-frontiers/index.html

to continue the development of the interaction portions of Virtual Bethel; to embed a curation experience; and to refine standardized workflows for creating multidevice VR executables for any audience or hardware such as Oculus, Vive (full VR), iOS and Android (mobile VR), and web-based versions of the experience (for those lacking HMD or mobile VR hardware). A graduate student with web development experience was also paid to develop the public facing website and store all of the content.[9]

Critical Decision-Making Points Through the Project Based on Stakeholder Feedback

Several critical decision-making points arose through the project, particularly in terms of VR navigation, curation of Bethel's story and history, implementation of audio and voice, protecting the cultural protocols of the Bethel congregation, and preservation community priorities with VR constraints.

Virtual Reality Navigation

During the first public showcase in the fall of 2017, we noted that many of the Bethel membership were elderly and took several minutes to learn to use VR navigation. Some members also were unable to stand because of their health. The decision was made and implemented immediately after that session to provide two modes of VR navigation when showcasing Virtual Bethel with HMDs: one standing mode with teleportation enabled, and a second sitting mode that would allow the user to transition to various locations preloaded in the Virtual Bethel sanctuary by clicking one button. Making the VR experience accessible to those who cannot stand or walk has become a key priority to building an alternative VR navigation interaction in projects for the future.

Curation of Bethel's Story and History

After the space was initially showcased to the local membership, Bethel resident historian and Virtual Bethel Curator, Olivia McGhee-Lockhart and several heritage partners were given the opportunity to experience the Virtual Bethel space. They expressed gratitude at the re-creation of the space, but said that the experience felt flat and lacked a sense of story, import, or exploration. We knew the space alone was not enough to educate or leave an impact on an audience, so we decided to embed interactive story vignettes (figure 3–3). The vignettes included short written content and surrounded digital versions of content such as scanned newspapers, ledgers, and photographs of Bethel and its membership. In the late fall of 2017, the team turned its attention to creating a database within Virtual Bethel so that it could outlive the VR team. Now Virtual Bethel can accept additional story vignettes that house various types of data.

[9] https://comet.soic.iupui.edu/bethel/

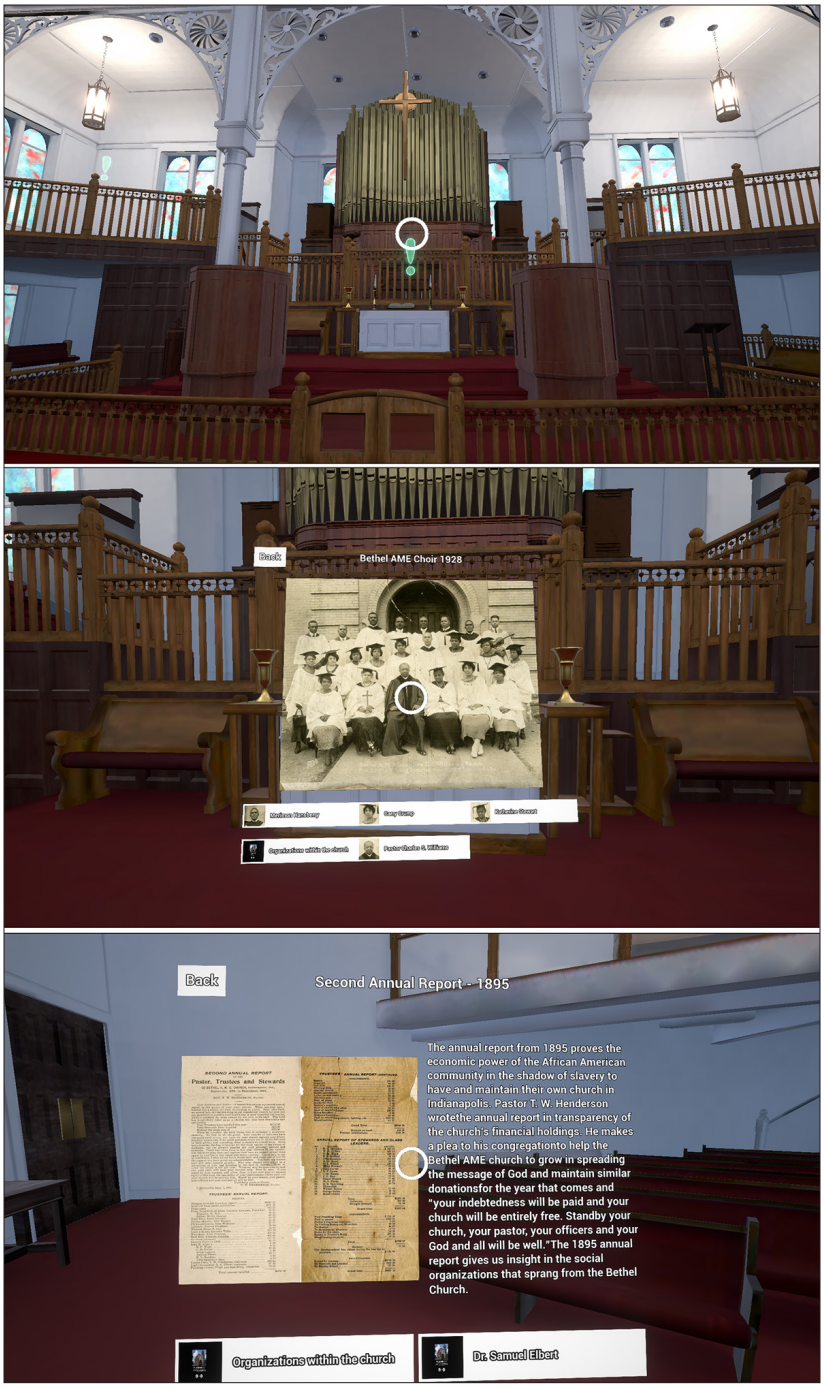


Fig. 3–3. *Examples of interactive story vignettes*

Implementation of Audio and Voice

On Martin Luther King Day, 2018, we were showcasing the latest version of Virtual Bethel, which then contained 20 story vignettes; we noticed several audience members saying that they would love to "hear" ambient church members and McGee-Lockhart, as a critical part of the vignette experience. As a result, McGee-Lockhart recorded audio for each vignette, discussing the history of specific parts of the church, and the audio was programmed to play upon interaction with the vignettes. This enriched the experience of the space for

users and enabled them to hear why each space was so important to its congregants and for the city of Indianapolis.

Plan for Sharing

Early in the relationship, because of the inexperience of project partners in both the game development processes and VR, we created contractual protections for Virtual Bethel that still make it legally difficult to share the project folders with interested parties. Our goal was to ensure safe, responsible, and ethical use of Virtual Bethel files, as we feared that ease of access could lead to unimagined and potentially harmful reuse of the digital files. We wanted to protect Bethel's membership from the possibility that a game or other interactive experience could be made based on the Virtual Bethel content without their express consent.

Preservation Community Priority Versus VR Constraints

Early in the project, stakeholders unfamiliar with the technical and hardware constraints of VR expected objects in virtual space to have the same level of realism and accuracy that objects have in real life. We explained to project stakeholders and community partners that varying levels of realism can be achieved based on the following factors: student labor force size, ability, and available time. We are very proud of our students' final version of Virtual Bethel and its level of realism/believability. In our opinion, it exceeds many other projects in both aesthetics and interaction.

Looking Ahead

As new technologies emerge, as virtual interactions become simpler to implement, and as alternate realities permit ever-richer experiences, new opportunities are continually emerging for research and application. Looking forward, we suggest some areas of research in which to invest prior to building a virtual recreation.

Agnostic Platforms

Project partners and stakeholders at IU used Virtual Bethel's methodology to recreate various spaces, but with significant differences; for example, some teams used Unity game development engine, while our team had used Unreal game development engines. This meant that project teams frequently could not use the virtual artifacts and interactions that others created. Developing across multiple software platforms can be cumbersome and often leaves one team feeling left behind the other. In MAS, we have committed to creating projects in both Unreal and Unity game development engines to both increase the employability of our students and to stay current with trends in these industry-leading applications for next-generation interactions.

UX Standards and Institutional Documentation

There is little documentation for developing platform-specific interaction standards for virtual reality. Documenting virtual interactions that do (and do not) work well, sharing the code that creates them, and explaining the reasoning and context behind the choices made during their creation is therefore critical to building a project management and knowledge-sharing infrastructure. What works well in a full VR experience for navigation and interaction must be configured separately for mobile devices and again for web-based virtual experiences on a desktop computer. The Virtual Bethel team has committed to delivering VR environments for all major platforms and to documenting the processes of creating interactions for each platform to aid future IU teams. Creating tools that automate the development of navigation and interaction inputs across VR platforms and devices will expedite the testing, evaluation, and accessibility of virtual reality-supported historical and cultural preservation projects.

Advanced Capture Technologies

Capturing 3D artifacts and spaces is becoming cheaper, more efficient, and more accurate every day. For example, we can now use a combination of photogrammetry-produced high-resolution textures with highly accurate spatial data from laser scanning—an approach that was not available to us when the project started two years ago. Documenting methods for combining geometry and textures from multiple imaging tools will be important as advanced capture technologies and techniques change over time.

Quantifying Authenticity

Throughout the creation of Virtual Bethel, our core concern was to recreate the chapel for the congregants. Each of the stakeholders we spoke with—the engineers scanning the space, the librarians scanning documents and artifacts, our students, the Bethel membership, or the public at large—had their own definition of what was real, true, or believable in virtual reality.

We began to frequently ask the following questions:

- How can we quantify authenticity of virtual objects/spaces for different stakeholders when forced to remake spaces/artifacts for VR experiences?
- What are the dependent variables in defining authenticity?
- Do digital born artifacts have authenticity as a digital replica?
- At what point does digitized content made for AR or VR not represent the physical artifact on which it is based?
- How much freedom does a 3D artist have?

Much effort was spent educating all project partners and stakeholders on the geometry, texture, and lighting constraints of VR (and limitations of student ability) while also convincing them to capture the highest possible quality of scans for posterity.

We believe that virtual reality will become the interaction

medium of choice for audiences to learn about and experience history. Watching Bethel congregants, students, children and colleagues interact with, gain insights from, and understand the VR medium and how Bethel is being preserved in a new way leads our team to believe this is a much more natural, believable, and accessible media environment with which to engage, educate, and entertain. As hardware adoption and the public's comfort interacting with digital content increases, preservationists will no longer just preserve, but will also have the opportunity to lead the curation of and interaction with the objects, spaces, and time periods they protect (see Costa and Melotti 2012; Morcillo et al. 2017).

Accessibility for All

Media Arts and Science at IUPUI is committed to making available and representing its students' and project partners' hard work in as many ways as possible. Until full head-mounted displays are ubiquitous in homes around the world, we see it as necessary and ethical to create full, mobile, and web-based VR iterations of all of our projects to ensure that all audiences can learn from the virtual spaces we create.

Conclusion

Throughout its creation, Virtual Bethel has benefited the faculty, students, librarians, preservationists, community partners, and, most important, Bethel church members. Positioning a 3D/VR production as a focal point for heritage preservation inspired quick stakeholder buy-in, enthusiasm, and flexibility through collective understanding. All stakeholders embraced this emerging technology as a unique preservation method. The IUPUI Library has become a place to learn about emerging technologies, anticipate trends, and preserve the digital files of productions such as Virtual Bethel. The Virtual Bethel project has become an exemplar of what a library can offer its public and how an academic institution can leverage faculty and on-campus resources while integrating its students into authentic and engaging curricular and co-curricular projects. Undergraduate students led the VR production day to day, and the result, with a bit of organization and regular community feedback, was more than anyone could have imagined. We could not be happier. During its creation, Virtual Bethel inspired six other preservation projects and student teams of varying sizes at IU. Virtual Bethel's success has inspired the integration of MAS students and faculty in the virtual re-creation of several environments and time periods in and around Indianapolis. The collaboration of community members, historians, preservationists, librarians, student game developers, and 3D artists realizes a new opportunity to develop exciting experiences that are authentic, accurate, and informative, both inside and outside of academia.

We did not just scan the Bethel AME church, we did not just document the space, we re-created it. Furthermore, we are preserving it

in a medium that will far outlive the physical church or anyone on the team. We embedded within the VR environment access to more history than the real space could ever provide, separate from any single historian, member, or moment. We made it possible to add and amend new content to the Virtual Bethel database at any time. We believe projects like Virtual Bethel are redefining what the preservation of an endangered cultural heritage site means. The scanning of 2D and 3D objects is the first step in a much larger preservation pipeline, one in which an audience readily accesses a space that no longer exists, listens to voices that can no longer be heard, and holds artifacts that no longer can be held. Future audiences will demand to interact with and understand history on their own terms, while a new niche of VR curators will initiate preservation projects, provide access, and steward the experience.

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